What is claimed is:

1. A projection optical system for imaging a first object into a region of a second object using light of a wavelength shorter than 250 nm, the projection optical system comprising:

a plurality of lenses disposed along an optical axis of the projection optical system;

wherein the plurality of lenses is dividable into four non-overlapping groups of lenses, such that

a total refractive power of a first group disposed closest to the first object is a negative refractive power,

a total refractive power of a second group disposed directly adjacent to the first group is a positive refractive power,

a total refractive power of a third group disposed directly adjacent to the second group is a negative refractive power, and

a total refractive power of a fourth group disposed directly adjacent to the third group is a positive refractive power;

and wherein the following relation is fulfilled:

$$2 \cdot y \cdot NA \cdot \frac{1}{k} \cdot \sum_{i=1}^{k} |\varphi_i| \geq V_1$$

wherein:

y is half a diameter in mm of a maximum image field imaged by the projection optical system,

NA is a maximum numerical aperture on a side of the second object,

φ_i is a refractive power in mm^{-1} of the i^{th} lens,

k is a total number of lenses of the projection optical system,

and wherein V_1 is greater than 0.045.

2. The projection optical system according to claim 1, wherein V_1 is greater than 0.055.

3. The projection optical system according to claim 1, wherein the following relation is fulfilled:

$$2 \cdot y \cdot NA \cdot \sin\left(\frac{1}{k} \cdot \sum_{i=1}^{k} |\delta_{i1}| + |\delta_{i2}|\right) \geq V_2$$

wherein:

y is half a diameter in mm of a maximum image field imaged by the projection optical system,

NA is a maximum numerical aperture on a side of the second object,

δ_{i1} is a maximum deflection angle of imaging beams at a first optical surface of the i^{th} lens,

δ_{i2} is a maximum deflection angle of imaging beams at a second optical surface of the i^{th} lens,

k is a total number of lenses of the projection optical system,

and wherein V_2 is greater than 4.

4. The projection optical system according to claim 3, wherein V_2 is greater than 5.

5. The projection optical system according to claim 1, wherein each of at least five lenses of the plurality of lenses has at least one aspherical surface.

6. The projection optical system according to claim 5, wherein an axial distance between the aspherical surface and a corresponding ideal spherical shape is more than about 300 µm and less than about 500 µm,

wherein the ideal spherical shape is chosen such that a center and a periphery of the aspherical surface are positioned on the ideal spherical shape.

7. The projection optical system according to claim 5, further comprising an aperture stop disposed between two lenses of the fourth group of lenses,

wherein the fourth group of lenses consists of a first sub-group of lenses in between the first object and the aperture stop and a second sub-group of lenses in between the aperture stop and the second object.

8. The projection optical system according to claim 7, wherein the following condition is fulfilled:

$$\frac{f_1}{f_2} < 0.9 \cdot |\beta|$$

wherein

f_1 is a focal length of a lens unit consisting of the first, second and third group as well as the first sub-group of the fourth group,

f_2 is a focal length of the second sub-group of the fourth group,

β is a magnification of the projection optical system.

9. The projection optical system according to claim 7, wherein the following condition is fulfilled:

$$\frac{f_1}{f_2} > 1.1 \cdot |\beta|$$

wherein

f_1 is a focal length of a lens unit consisting of the first, second and third group as well as the first sub-group of the fourth group,

f_2 is a focal length of the second sub-group of the fourth group,

β is a magnification of the projection optical system.

10. The projection optical system according to claim 1, wherein the following condition is fulfilled:

$$\frac{L_D \cdot D_{beam} \cdot \log\left(\frac{1}{NA}\right)}{100 \cdot FD} < 3$$

wherein

L_D is a design-distance between the first object and the second object,

D_{beam} is a maximum diameter of the beam bundle

NA is a maximum numerical aperture on a side of the second object, and

FD is a maximum field-height of the first object.

11. The projection optical system according to claim 7, wherein a radial surface profile of the aspherical surface has at most one point of inflection of curvature.

12. The projection optical system according to claim 11, wherein a radial surface profile of at most one aspherical surface has a point of inflection of curvature in an optically effective area of the aspherical surface.

13. The projection optical system according to claim 1, wherein a focal length of the projection optical system is shorter than 250 mm.

14. The projection optical system according to claim 7, wherein at least one lens in the second sub-group of the fourth group of lenses is a lens of positive refractive power and wherein the at least one lens fulfils the following conditions:

$$i_1 \cdot (u_{1i} + u_{1o}) + i_2 \cdot (u_{2i} + u_{2o}) > 2.5 \quad \text{and}$$
$$f_{4p} < 2500\ \text{mm}$$

wherein

i_1 is a maximum angle of incidence of an imaging beam on a first surface of the at least one lens,

i_2 is a maximum angle of incidence of the imaging beam on a second surface of the at least one lens,

u_{1i} is a maximum angle formed between the imaging beam and the optical axis at the first surface outside of the at least one lens,

u_{2i} is a maximum angle formed between the imaging beam and the optical axis at the second surface inside of the at least one lens,

u_{1o} is a maximum angle formed between the imaging beam and the optical axis at the first surface inside of the at least one lens,

u_{2o} is a maximum angle formed between the imaging beam and the optical axis at the second surface outside of the at least one lens, and

f_{4p} focal length of the at least one lens.

15. The projection optical system according to claim 1, wherein the first group of lenses is comprised only of lenses having negative refractive power, wherein one of the lenses of the first group is a meniscus lens having a concave surface facing the first object.

16. The projection optical system according to claim 1, wherein the second group of lenses is comprised only of lenses having positive refractive power, wherein at least one of the lenses of the second group has a concave, aspherical surface.

17. The projection optical system according to claim 1, wherein the second group of lenses comprises at least three lenses.

18. The projection optical system according to claim 1, wherein at least one lens of the third group of lenses has an aspherical surface.

19. The projection optical system according to claim 1, wherein the third group of lenses is comprised only of lenses having negative refractive powers.

20. The projection optical system according to claim 19, wherein the third group of lenses comprises three or more lenses of negative refractive powers.

21. The projection optical system according to claim 1, wherein a lens having positive refractive power is disposed between two lenses having negative refractive powers in the third group of lenses.

22. The projection optical system according to claim 7, wherein

the first sub-group of lenses comprises at least one lens of negative refractive power having a first and a second surface,

which lens fulfils the following condition:

$$\left|\frac{c_{11}+c_{12}}{c_{11}-c_{12}}\right| < -0.5$$

wherein

c_{11} is a curvature of the first surface of the at least one lens and

c_{12} is a curvature of the second surface of the at least one lens.

23. The projection optical system according to claim 7, wherein

the first sub-group of lenses comprises 2 to 4 lenses of positive refractive powers.

24. The projection optical system according to claim 7, wherein

the first sub-group of lenses comprises at least one lens of negative refractive power having a first and a second surface,

which lens fulfils the following condition:

$$\left|\frac{c_{21}+c_{22}}{c_{21}-c_{22}}\right| > 0.5$$

wherein

c_{21} is a curvature of the first surface of the at least one lens and

c_{22} is a curvature of the second surface of the at least one lens.

25. The projection optical system according to claim 7, wherein

the second sub-group of lenses comprises only one lens having negative refractive power.

26. The projection optical system according to claim 7, wherein

the second sub-group of lenses comprises a lens having negative refractive power disposed adjacent to a lens having positive refractive power, with the lens having positive refractive power being positioned closer to the second object, and wherein the negative lens fulfils the following condition:

$$\left|\frac{c_{31}+c_{32}}{c_{31}-c_{32}}\right| < -0.5$$

wherein

c_{31} is a curvature of the first surface of the at least one lens and

c_{32} is a curvature of the second surface of the at least one lens.

27. The projection optical system according to claim 7, wherein

the second sub-group of lenses comprises a lens having positive refractive power disposed adjacent to a lens having negative refractive power, with the lens having negative refractive power being positioned closer to the second object, and wherein the negative lens fulfils the following condition:

$$\left|\frac{c_{41}+c_{42}}{c_{41}-c_{42}}\right| > 0.5$$

wherein

c_{41} is a curvature of the first surface of the at least one lens and

c_{42} is a curvature of the second surface of the at least one lens.

28. The projection optical system according to claim 7, wherein

the second sub-group of lenses comprises no less than two and no more than four positive meniscus lenses having their concave surfaces facing the second object.

29. The projection optical system according to claim 7, wherein the first group of lenses contains a maximum of 2 aspherical lenses,

the second group of lenses contains a maximum of 2 aspherical lenses,

the third group of lenses contains a maximum of 1 aspherical lens,

the first sub-group of the fourth group of lenses contains a maximum of 3 aspherical lenses, and

the second sub-group of the fourth group of lenses contains a maximum of 3 aspherical lenses.

30. The projection optical system according to claim 7, wherein in the second sub-group of the fourth group of lenses, any lens having an aspherical surface has the aspherical surface on a side of the lens facing the second object.

31. The projection optical system according to claim 7, wherein in the first group of lenses, any lens having an aspherical

surface has the aspherical surface on a side of the lens facing the first object.

32. The projection optical system according to claim 1, wherein the following condition is fulfilled:

$$\frac{L_D}{G_D} > 1.4$$

wherein

G_D is a sum of axial thicknesses of all the lenses, wherein the axial thickness of each lens represents a thickness of the lens at a location on the optical axis,

L_D is a design-distance between the first object and the second object.

33. The projection optical system according to claim 1, wherein all lenses are made of calcium fluoride.

34. The projection optical system according to claim 1, wherein all lenses are made of silica.

35. The projection optical system according to claim 1, wherein one or more crystalline materials are used as lens materials.

36. The projection optical system according to claim 35, wherein the crystalline materials comprise a fluoride material.

37. The projection optical system according to claim 36, wherein one or more of the four lenses disposed closest to the second object are made of a fluoride material, wherein a crystal orientation of the fluoride material in the one or more lenses with respect to the optical axis is the same in two or more lenses.

38. The projection optical system according to claim 35, wherein one ore more lenses of the second and/or third group of lenses is made of a fluoride material.

39. The projection optical system according to claim 35, wherein one of the positive lenses in the fourth group of lenses is made of a fluoride material.

40. The projection optical system according to claim 1, wherein the projection optical system further comprises an adjustable aperture stop, wherein an axial position of an aperture formed by the aperture stop varies with the size of the aperture, wherein the axial position of the aperture is defined by an intersection of a plane defined by the aperture and the optical axis.

41. The projection optical system according to claim 40, wherein the adjustable aperture stop comprises lamellae having an essentially planar shape.

42. The projection optical system according to claim 40, wherein the adjustable aperture stop comprises lamellae essentially all of which have an identical spherical shape.

43. The projection optical system according to claim 1, wherein a numerical aperture of the projection optical system on a side of the second object is greater than 0.91.

44. The projection optical system according to claim 1, wherein the fourth lens group comprises at least one pair of directly adjacent lenses, wherein a first lens of the pair of lenses has a first and a second surface and a second lens of the pair of lenses has a third surface and a fourth surface, and wherein the first, second, third and fourth surfaces are disposed along the optical axis in this order, and wherein the following conditions are fulfilled:

$$d < V_5$$

$$\left|\frac{c_{51}+c_{52}}{c_{51}-c_{52}}\right| > V_6$$

$$c_{51} > V_7$$

wherein

d is a maximum distance between the second surface and the third surface,

c_{51} is a curvature of the first surface,

c_{52} is a curvature of the fourth surface, and

$V_5 = 15$ mm, $V_6 = 10$, $V_7 = 0.003$ mm^{-1}.

45. A projection optical system for imaging a first object into a region of a second object using light of a wavelength shorter than 250 nm, the projection optical system comprising:

a plurality of lenses disposed along an optical axis of the projection optical system;

wherein the plurality of lenses is dividable into four non-overlapping groups of lenses, such that

a total refractive power of a first group disposed closest to the first object is a negative refractive power,

a total refractive power of a second group disposed directly adjacent to the first group is a positive refractive power,

a total refractive power of a third group disposed directly adjacent to the second group is a negative refractive power, and

a total refractive power of a fourth group disposed directly adjacent to the third group is a positive refractive power;

and wherein the following relation is fulfilled:

$$2 \cdot y \cdot NA \cdot \sin\left(\frac{1}{k} \cdot \sum_{i=1}^{k} |\delta_{i1}| + |\delta_{i2}|\right) \geq V_2$$

wherein:

y is half a diameter in mm of a maximum image field imaged by the projection optical system,

NA is a maximum numerical aperture on a side of the second object,

δ_{i1} is a maximum deflection angle of imaging beams at a first optical surface of the i^{th} lens,

δ_{i2} is a maximum deflection angle of imaging beams at a second optical surface of the i^{th} lens,

k is a total number of lenses of the projection optical system,

and wherein V_2 is greater than 4.

46. The projection optical system according to claim 3, wherein V_2 is greater than 5.

47. A projection optical system for imaging a first object into a region of a second object using light of a wavelength shorter than 250 nm, the projection optical system comprising:

a plurality of lenses disposed along an optical axis of the projection optical system;

wherein the plurality of lenses is dividable into four non-overlapping groups of lenses, such that

a total refractive power of a first group disposed closest to the first object is a negative refractive power,

a total refractive power of a second group disposed directly adjacent to the first group is a positive refractive power,

a total refractive power of a third group disposed directly adjacent to the second group is a negative refractive power, and

a total refractive power of a fourth group disposed directly adjacent to the third group is a positive refractive power;

wherein each of at least five lenses of the plurality of lenses has at least one aspherical surface,

wherein an axial distance between the aspherical surface and a corresponding ideal spherical shape is more than about 300 µm and less than about 500 µm,

wherein the ideal spherical shape is chosen such that a centre and a periphery of the aspherical surface are positioned on the ideal spherical shape.

48. The projection optical system according to claim 45, wherein each of the at least five aspherical surfaces having an effective diameter D_{as} has a centre of curvature of the corresponding ideal spherical shape disposed on a side of the aspherical surface facing away from the lens carrying the aspherical surface, and wherein D_{as} is 0.2 times a design-distance L_D between the first object and the second object.

49. The projection optical system according to claim 45, wherein an absolute value of a maximum change of curvature of the aspherical surface is greater than 300 m^{-2}.

50. A projection optical system for imaging a first object into a region of a second object using light of a wavelength

shorter than 250 nm, the projection optical system comprising:

a plurality of lenses disposed along an optical axis of the projection optical system;

wherein the plurality of lenses is dividable into four non-overlapping groups of lenses, such that

a total refractive power of a first group disposed closest to the first object is a negative refractive power,

a total refractive power of a second group disposed directly adjacent to the first group is a positive refractive power,

a total refractive power of a third group disposed directly adjacent to the second group is a negative refractive power, and

a total refractive power of a fourth group disposed directly adjacent to the third group is a positive refractive power;

and wherein the following relation is fulfilled:

$$\frac{G_D}{2 \cdot y \cdot NA} \leq V_4$$

wherein:

y is half a diameter in mm of a maximum image field imaged by the projection optical system,

NA is a maximum numerical aperture on a side of the second object,

G_D is a sum of all axial thickness of the lenses, wherein the axial thickness of each lens represents a thickness of the lens at a location on the optical axis,

and wherein V_4 is smaller than 40.

51. The projection optical system according to claim 50, wherein V_4 is smaller than 35.

52. A projection exposure system, comprising:

an illumination optical system for generating a light beam of light having a wavelength shorter than 250 nm;

a mount for mounting a patterning structure as a first object;

a substrate mount for mounting a radiation sensitive substrate as a second object; and

the projection optical system according to one of claims 1 to 51, for imaging the first object into a region of the second object.

53. A method of manufacturing a microstructured device, comprising:

using a projection exposure system, comprising:

an illumination optical system for generating a light beam of light having a wavelength shorter than 250 nm;

a mount for mounting a patterning structure as a first object;

a substrate mount for mounting a radiation sensitive substrate as a second object; and

the projection optical system according to one of claims 1 to 51, for imaging the first object into a region of the second object; and

imaging the patterning structure onto the radiation sensitive substrate with the light beam of the light having the wavelength shorter than 250 nm.

54. A microstructured device manufactured by a method, the method comprising:

using a projection exposure system, comprising:

an illumination optical system for generating a light beam of light having a wavelength shorter than 250 nm;

a mount for mounting a patterning structure as a first object;

a substrate mount for mounting a radiation sensitive substrate as a second object; and

the projection optical system according to one of claims 1 to 51, for imaging the first object into a region of the second object; and

imaging the patterning structure onto the radiation sensitive substrate with the light beam of the light having the wavelength shorter than 250 nm.